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INTRODUCTION

The Lima Declaration and Plan of Action on Industrial Development and Co-operation placed particular emphasis on the "promotion of an integrated industrialization process based on the potential of each country".[1] The achievement of this aim will require the greatest possible degree of interaction between industry and other institutions involved in economic development, notably universities and research institutes.

These institutions have an important role to play in providing both the trained manpower and the technical know-how needed for industrialization. To play that role effectively, they need to co-operate so that requirements and the resources available to meet them are properly related.

One aspect of this co-operation, that between industry and the universities, was the subject of an expert group meeting organized by the United Nations Industrial Development Organization (UNIDO) at Vienna in 1973. This meeting was very useful and led UNIDO to expand its technical assistance programmes, particularly in the management field. The meeting identified significant advantages to industry, universities and society. The following paragraphs are quoted from Industry-University Linkage, with Special Reference to Management.[2]

Advantages to industry

From linkage with the university, industry stands to gain:

A supply of better qualified graduates having more relevant training because industry's needs have been identified;

Access to a variety of post-experience training facilities it has helped to design;

Access to the university's physical facilities and the expertise of its staff;

Access to the research, consulting and data collection of the university;

An improved public image in the society in which it operates, which means that more talented students will be attracted to the industrial sector.

Advantages to the university

The advantages to the university are no less real and include:

The opportunity to assess the needs of the economy and to develop its activities accordingly;

The opportunity to place students in industry so that classroom learning can be related to practical experience;

1/ ID/Conf.3/31, chap. IV, para. 58(c).

2/ United Nations publication, Sales No. 74.II.B.9, pp. 3-4.

Assistance from industry in curriculum development to ensure that curricula shall be relevant to local conditions;

Strengthening staff development by giving faculty members opportunities to gain practical experience;

Access to industry for both fundamental and applied research.

Advantages to society

Finally, the economy as a whole benefits from industry-university interaction through:

An improved return on investment in higher education;

A more effective educational contribution to economic development;

Better utilization of human and physical resources;

Fewer of the social and political stresses that accompany unemployment of university graduates.

This link between industry and university is clearly important, but there is also another - the link with the research institutes that have been set up in both industrialized and developing countries. Industrial research is recognized as an important element in industrial development, for it is the focal point of innovation and technological improvement. But it is not sufficient for the developing countries simply to follow the models adopted in industrialized countries. Conditions vary enormously from country to country, and technological developments need to be appropriate to local situations. So do the institutions in which they take place. For this reason, developing countries cannot rely solely upon the research and development undertaken in industrialized countries; they must develop their own institutions and research policies.

As a step in mobilizing available resources for the rapid industrialization of developing countries, one of the main objectives of UNIDO, the Expert Group Meeting on Co-operation among Universities, Industrial Research Organizations and Industries and the Role of UNIDO in this Co-operation was held at Vienna from 29 November to 3 December 1976. The main purpose of the Meeting was to promote the establishment of links and co-operation among these institutions as well as between them and UNIDO with a view to assisting the industrialization of developing countries and to improving technical assistance, training and advisory services in these countries.

The Meeting discussed the role of industry in establishing co-operation between universities and research institutes from industrialized countries and those of developing countries, and how UNIDO could assist in establishing

and accelerating interinstitutional collaboration.

The participants were all persons in responsible positions who had practical experience in promoting co-operation among industry, universities and research organizations. The discussions were, therefore, based on experience rather than hypothesis or general principle. Indeed, it was accepted that co-operation was desirable and attention was concentrated upon how to achieve it.

At the opening plenary session F. Garrana (Egypt) was elected Chairman and N.C. Hunt, Rapporteur, after which the participants formed three working groups, representing industry, universities and research institutes. Each group, however, contained representatives of the other two parties so that the opportunities for co-operation and the problems in achieving it could be considered realistically.

RECOMMENDATIONS

Having considered the range of experience brought to the Expert Group Meeting by participants from both industrialized and developing countries and being convinced of the importance of co-operation among industry, universities and research institutes, the Meeting recommended that the following measures be taken to promote such co-operation:

1. UNIDO should give high priority to assisting developing countries to plan for co-operative research and development as an essential element in industrialization.
2. UNIDO should fully brief its field advisers on all aspects of such co-operation so as to identify needs and resources and to provide advice on how to secure effective co-operation.
3. Since UNIDO strategy must take into account the industrial development policies of developing countries, it should ascertain the areas in which the promotion of co-operation is most urgent. The UNIDO International Centre for Industrial Studies should be asked to undertake the research necessary to identify these priorities.
4. UNIDO should undertake or contract out a pilot survey in perhaps four representative developing countries to evaluate needs and the degree to which they have been met by the various forms of linkage that have been adopted.
5. UNIDO should also undertake a survey to identify resources available to promote co-operation in research and development. The survey would be based on questionnaires distributed to selected industries, universities and research institutes.
6. UNIDO should organize workshops in developing countries for the exchange of experience in co-operation, with UNIDO paying the fares of participants and the host country meeting local costs. The workshops might be financed under the UNIDO scheme for promoting exchange of experience between developing countries.
7. Existing national committees of UNIDO should seek to promote co-operation among industry, universities and research institutes both nationally and internationally.

8. In association with recommendation 7, honorary UNIDO "correspondents" should be appointed, where appropriate, in universities and research institutes in industrialized countries. There they could influence their institutions to concern themselves more with developing countries and also give overseas students a better understanding of the importance of linkage and of the role of UNIDO in promoting it. These correspondents should organize periodic meetings to create a greater awareness in industrialized countries of the need for co-operation and of the work of UNIDO. Local costs would be met by the host country, with UNIDO financing the participation of its staff and visiting speakers.

9. National and regional centres for the transfer of technology should be encouraged to concern themselves with co-operation among industry, universities and research institutes. They could provide a valuable agency for ensuring that developing countries gain the undoubted research and development advantages afforded by the presence of the transnational corporations.

10. Whenever UNIDO undertakes an industrial development project, it should consider whether linkage between industry universities and research institutes could thereby be promoted, for example, by pairing suitable institutions. Likewise, when big industrial contracts are negotiated with overseas companies, it should be required that some of the research and development be done in local institutions.

11. In the course of negotiating development projects, UNIDO should ensure that the top government officials concerned (often in several departments) shall be made aware of the importance of co-operation among industry, universities and research institutes. This may well require a conscious effort, since each may be under a different ministry, e.g. universities under the Ministry of Education, industry under the Ministry of Industry, and research institutes under the Ministry of Science and Technology.

12. UNIDO should always seek to ensure that in carrying out projects contact is maintained with other United Nations and bilateral agencies involved, i.e. that United Nations agencies should themselves set an example of co-operation. For example, the World Bank uses local institutions to do feasibility studies and UNIDO could perhaps exert its influence to ensure that these projects encourage co-operation rather than competition between institutions.

Part one

REPORT OF THE EXPERT GROUP MEETING

I. OBJECTIVES OF CO-OPERATION

No country has sufficient resources to do all that it might wish. The developing countries, however, often lack the resources to do even those things that would be regarded as essential in industrialized countries. One of the scarcest of scarce resources in these countries is highly trained manpower, especially the kind needed for research and development. As a result, developing countries have to import technology from the highly industrialized countries, which gives rise to a sort of "technological colonialism" that inhibits their freedom to develop their economies in their own way.

This problem becomes apparent when the role of the transnational corporations in economic development is examined. The countries in which they operate need their investment to develop the economy and provide jobs.

The corporations bring with them valuable know-how that can be passed on to the nationals of the host country through extensive and sophisticated training schemes. Indeed, the transnationals are often in the forefront in training local cadres and in setting high standards of commercial citizenship. But if they insist upon importing all their research and development from their home countries, the host country will remain in a position of technological and economic dependence, which it will find increasingly unacceptable.

Banning the transnationals or making their continued operation uneconomic is not the solution to the problem; they are needed and they can be among the most powerful allies of economic development. But they should be linked to the host country's embryonic resources for research and development, usually to be found in its universities and industrial research institutes. Then they can play a vital part in building up the research and development facility that the host country needs.

Co-operation, therefore, among industry - both local and international - universities and research institutes is required because of the shortage of research and development resources in the developing countries. It is also required because science, education, research and development can only play their part to the full if their goals, policies and methods are consistent with those of the developing country. In the transfer of technology, imitation without local innovation or at the very least adaption can only

inhibit the full realization of the economic potential of a developing country. Yet, at the same time, if developing countries are to move into a position where they can prosper in a competitive world economy, their technology must be compatible with that of industrialized countries.

The position may be summarized thus:

"(a) Industrial advancement is a very broad-based process that encompasses the modernization of agricultural, transportation, communications, energy, urban and social systems, as well as the implantation of manufacturing industry;

(b) The technology to be used should be appropriate to the physical, human and capital resources available and to the economic, social and political parameters determining their optimal employment;

(c) Progress with industrialization of the developing countries has taken them to the stage where they have no choice but to adopt technology compatible with that of the industrialized countries, to enable the former to compete effectively in an interdependent world;

(d) Developing countries need to greatly increase indigenous capabilities for analysing socio-economic implications of the technological and other changes they seek. These countries need help in sharpening their skills in systems analysis, decision analysis, intelligence evaluation, forecasting and long-range planning." 3/

The emphasis, therefore, is not simply upon industrialization, but rather upon modernization of the whole economy in a way that is consistent with social needs. Since those needs vary so greatly from country to country and over time, reliance upon imported research and development is inadequate; an effective local research facility is essential. Moreover, this total research facility should encompass and co-ordinate resources to be found in all three probable locations, namely, industry, universities and research institutes.

This is, of course, easier said than done. Whereas some two thirds of research capacity in industrialized countries is likely to be industry-based, most industrialized plants in developing countries have little or no research capacity. Consequently, these countries tend to concentrate their research capacity in independent research institutes, often financed and, indeed, controlled by government. This policy may well be necessary at the earlier stages of economic development, but it has its own inbuilt problems. Research and development capacity needs to be planned consciously within the framework of large, modern industrial enterprises. The lack of research

3/ Statement of Wilson F. Harwood, Stanford Research Institute.

facilities within industry is a serious limitation on economic development and economic independence.

An associated problem is that government-sponsored research institutes often seem to develop an excessively "academic" approach to their task; they become part of the State bureaucracy and lack any financial incentive to relate their research to the requirements of industry. The universities may well take the same position and rationalize it in terms of "academic freedom"; their staffs rarely have significant industrial experience, and their goals are often inconsistent with those of industry and commerce - indeed, they may even be antagonistic.

Therefore, governments of developing countries urgently need to stimulate linkage between industry, research institutes and universities to ensure that their policies serve the real needs of the society in which they are located. For example, in starting up the Materials Research Unit at the Marmara Scientific and Industrial Research Institute in Turkey,[4] a UNIDO consultant was engaged to make a survey of research requirements to ensure that the facilities and programmes would correspond with real, identified needs.

The word "research" can easily be given an unnecessarily restricted meaning. It includes investigations to solve operating problems and provision of technical services as well as "pure" and "applied" research in the academic sense. Thus, a continuous dialogue between the providers and the users of research facilities is required. The Shirley Institute in Manchester, which serves the textile industries, has a deliberate policy of providing technical services rather than conventional research, but with the back-up of highly trained scientists who are themselves engaged in research.

In planning the co-ordination of research facilities to meet social needs, the role of market research is often neglected. The techniques of market research should be more widely used than at present to identify needs and to mould government policy accordingly.[5] At present, it is often foreign private investors who use these techniques, rather than governments or international agencies. Market research is particularly important in providing feedback on changes in consumer tastes as economic

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4/ See Part two, chapter XI.

5/ See Part two, chapter II.

development proceeds.

The rise of the so-called "consumer movement"[1] could be important for the future research policies of developing countries. In the industrialized countries, consumer organizations work closely with governments, universities and research institutes in developing and executing testing and research programmes. More recently they have established contact with their opposite numbers in developing countries, some of which have now set up their own testing and research programmes. Without this kind of organized pressure from consumers, research and development policies may get out of step not only with the needs of industry, but also with those of the ultimate consumers, and thereby inhibit the development of a truly indigenous modernization programme.

Thus, linkage between industry, universities and research institutes is necessary because of (a) scarcity of research resources; (b) the need to develop indigenous technologies; and (c) the importance of ensuring that research policies shall be demand-based rather than supply-based. However, it is one thing to establish the importance of linkage; it is another thing altogether to achieve it. Consequently, the Expert Group Meeting rightly considered that it should spend most of its time examining ways of achieving effective linkage rather than arguing the case for it. Exhortations to co-operate are likely to achieve little; there must be a common interest in and incentive to co-operate. The following chapters examine these prerequisites for linkage in some detail.

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[1] See Part two, chapter XIX.

II. MOTIVATION TO CO-OPERATE

Each of the three working groups representing, respectively, industry, universities and research institutes, considered the following questions:

What do you expect to gain by co-operation?

What can you offer the other two parties?

What forces inhibit co-operation?

What factors promote co-operation?

What institutional forms have been found effective?

What can UNIDO do to promote co-operation?

What can you do to assist UNIDO to promote co-operation?

This chapter summarizes comments of the working groups on the first two questions and the discussion of them that took place in the subsequent plenary session. The importance of the first question lies in the belief that co-operation will not, in fact, take place unless each party gains something specific from it. Thus, it is the key question and for this reason was dealt with first.

Industry expects to gain the following advantages from co-operation with universities:

An adequate flow of qualified personnel well prepared for work in industry because they have taken suitable courses

Opportunities for continuing education for personnel to update skills or acquire new ones

Advisory and consultancy services to deal with practical problems

Assistance in developing indigenous technologies making use of indigenous raw materials

Contract or sponsored research, with a financial criterion of success

Assessment and forecasting of consumer needs and long-term environmental changes, economic, social and political

Establishment of jointly staffed research groups with industry and research institutes

Access to laboratory, testing and other physical facilities

From co-operation with research institutes, industry expects to gain the following:

A re-definition of their role so that they become more client-oriented, and financially self-supporting

Consultancy and advisory services on patents, process design and development, product development, quality control, and capital expenditure

Testing facilities

Possibility of technical training for staff

Trouble-shooting

Assistance in negotiating with plant and instrument suppliers

Techno-economic forecasting

Exchange of technical information

Access to research institutes in other countries

Continuous interaction with the institutes, exemplified by the presence of industrialists on the boards of management of the institutes

Universities expect to gain the following advantages from co-operation with industry:

Improvement in the quality of teaching resulting from interaction with industry; use of practitioners as part-time lecturers, who present examples of case studies culled from industrial experience and thus complement the academic work of the full-time staff

Contact with large corporations for transfer of technology, including management technology

Placement of students in industry to gain practical experience

Assistance in developing curricula designed to meet the real economic and social needs of the society

Protection from criticism of "irrelevance" and the consequent danger of government infringement of academic freedom

Higher status and greater acceptance in the society

Income, both corporate and personal, deriving from faculty research and consultancy

Greater job satisfaction and personal development for staff

From co-operation with research institutes, universities expect to gain the following:

Deeper knowledge of specific industries and understanding of practical problems to enrich teaching and research

Consultancy contracts where research institutes do not have the necessary skills themselves

Transfer of technology from the research institutes of transnational corporations

Research institutes expect to gain the following from co-operation with industry:

Greater likelihood of the institutes' achieving their major objective, that of contributing effectively to the industrialization and modernization of the country

Development of appropriate technologies, i.e. those that are relevant to local circumstances of employment, natural resources, availability of capital and government policy

Evolution of a research policy distinct from that followed by the universities, i.e. one that is related to solving the practical problems of industrial clients, often on a confidential, unpublishable basis and not necessarily advancing fundamental knowledge; co-operation to develop such a policy is necessary in order to succeed financially without government support

From co-operation with universities, research institutes expect to gain the following:

Common use of research facilities, resulting in the better use of scarce resources

Staff co-operation where the university possesses skills not found in the research institute

Staff exchanges, preferably on a project-by-project basis

Influence on university curricula so as to relate these more closely to the needs of industry

Spin-off advantage from having university staff and students undertaking joint projects with the research institute, e.g. for theses required for higher degrees

Benefits deriving from use of joint research teams

The above paragraphs summarize the findings of the three working groups regarding the primary motivation to co-operate, i.e. the specific advantages each party can gain from co-operating with the others. The other side of the coin is, of course, what each party can offer to the others. In so far as these correspond with the expected gains, there is the greatest likelihood of successful co-operation. Summarized below, therefore, are the working groups' findings as to what each party can offer the others.

Industry can offer universities the following:

Assistance in orienting themselves to industrial needs

Advice on university policy, given through professional associations, chambers of commerce etc.

Research and consultancy contracts providing financial incentives to faculty, e.g. by taking licences on new developments

Scholarships and internships for students

Liaison officers to develop ties between industry and university

Part-time and special lecturers

Persons to serve on university advisory committees

Facilities for testing out new processes

Financial assistance

Industry can offer research institutes:

Remunerative research and consultancy contracts

Training for institute staff

Persons to serve on institute boards and committees

Universities in developing countries vary enormously in their resources of manpower and physical facilities and pursue diverse academic policies. In some countries they are multifaculty institutions with highly independent and academic policies. In others they are essentially technical universities, concentrating largely on science and technology with a distinct industrial orientation. Not all universities, therefore, can offer all the items listed below or, indeed, would regard it as their proper role to do so. Nevertheless, they may be able to offer to industry:

Physical and manpower facilities for research, consultancy and training, especially to the smaller, local firms that cannot afford their own research and development sections

Expertise for updating knowledge and imparting innovative ideas to industry

Multidisciplinary research, consultancy and training teams

The results of fundamental research that industry can then translate into commercial ventures to the benefit of the economy as a whole

There is, perhaps, rather less that universities can offer to research institutes, but some of the facilities mentioned above may be of value to them as well as to industry. For example, some developing countries may not be able to afford fully equipped universities and research institutes, and some sharing of both facilities and staff may be necessary. Such sharing can, indeed, be constructive in that the skills of academic and industrial researchers may be complementary.

Research institutes, provided that they are in tune with the needs of industry, through close co-operation can provide to industry:

Development of new products, processes and techniques

Techno-economic studies

Market research

Technology transfer

Management consultancy

Technical services

Problem solving and trouble-shooting

Stimulus to industrial innovation

By co-operating with universities, they can provide:

Assistance in orienting academic policy towards the needs of industry

Joint research and consultancy teams

Common resources and services

Staff exchanges

Facilities for postgraduate student training

Some fundamental factors must be borne in mind. One is the great diversity of problems, resources and policies in different countries. Consequently there is no one ideal model of co-operation. Each country has to work out its own solution and not slavishly follow the example of some other country, particularly if it is at a fundamentally different stage of economic development. In fact, the experience of other developing countries may well be more relevant than that of industrialized countries.

A need common to all developing countries is university graduates capable of making rapid and significant contributions to economic and social development and motivated to do so. Close collaboration with industry and with government is necessary to meet this need, and the many, often conflicting, objectives of universites must be reconciled. This problem is discussed further in the next chapter.

The roles of the three parties may not always be clearly differentiated, with the result that there is wasteful overlap and scarce resources are misused. In attempting to relate to the short-term needs of the economy, universities may undertake tasks that are more appropriate to research institutes or to industry itself. They may also neglect their more important task of exploring long-term socio-economic-political trends and developing technological and other solutions to the problems they pose.

It is easier for research institutes to co-operate with industry than it is for universities; their objectives are simpler and more consonant with industry's needs. Nevertheless, in seeking enhanced status, they may aspire to the apparent prestige of universities by undertaking work for which they are not particularly suited. The solution, which is considered more fully in a later chapter, is to submit their work to the test of the market and to keep government subsidies to a minimum.

III. FACTORS INHIBITING AND FACILITATING CO-OPERATION

Among the factors inhibiting co-operation among industry, universities and research institutes are the following:

Different goals, ways of thinking and approaches to problems

Lack of common long-term objectives

Differing time scales of operation

Differing educational levels and the resultant academic snobbishness on the one hand and claims of irrelevance on the other

Differences in financing; universities are usually independent, government-financed institutions, whereas industry and research institutes are more exposed to market pressures

Poor communications, resulting in failure to match industrial needs with scientific resources

Artificial boundaries between academic disciplines inhibiting multidisciplinary tackling of practical problems

Isolation of government-financed institutions from industrial problems

Inadequate national strategy and government policies for industrial development

Lack of finance, equipment and expertise

Unimaginative managements

Hostility of some academics to involvement with industry

Failure by universities to recognize successful consultancy as a qualification for promotion

Basic differences in the subcultures of universities and industry, less in the case of technical universities than multifaculty, traditional ones

By contrast, the following are some of the factors encouraging co-operation:

Good channels of communication enabling resources to be matched to needs

Personal involvement and commitment of individuals, supported by a suitable reward system

Mobility of personnel between industry, universities and research institutes

Project-based teaching by universities, whereby staff and students actually tackle real problems

Machinery specifically designed for liaison,[7] and preferably self-financing

Physical proximity or accessibility

Soundly based contractual relationships that subject research and consultancy to the test of the market

Industrial representation in the government of universities and research institutes [8]

Suitable university and institute staff serving on boards of directors of industrial concerns

Provision of tax incentives to encourage industry to sponsor research in universities and research institutes

Government insistence that government-awarded contracts in which the research element is important contain a clause requiring involvement of the university and/or research institute

Governmental, bilateral and multilateral assistance to build up research and consultancy facilities in universities and research institutes

Action to ensure that technological benefit shall be derived from the presence of transnational corporations

The more important factors affecting co-operation can be summarized under five headings: (a) policy; (b) involvement; (c) contract; (d) research; and (e) training.

Policy

Co-operation is unlikely to happen by accident. It must be deliberately planned for as a matter of policy, backed by a suitable system of rewards and penalties.

Experience in Egypt illustrates this point clearly.[9] Despite goverment policy to establish the Egyptian National Research Centre as a link between research and industry, the objectives have not been fully achieved because of bureaucratic procedures, a promotion system based on academic reputation rather than effectiveness in solving real problems, and funds. Where success has been achieved, it has been the result of more positive attitudes on both

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7/ See Part two, chapter I.

8/ See Part two, chapter XVII.

9/ See Part two, chapter V.

sides, financial incentives for research staff, identification of suitable problems, the development of a research facility within the industrial enterprise with the assistance of centre consultants, and the adaption of imported technologies to local conditions rather than trying with inadequate resources to do basic research.

In India, the Government in its Fifth Five-Year Plan (1974-1978) deliberately planned for industry-university collaboration and charged the new Department of Science and Technology with promoting it.[10/] Resources were made available, and the major institutes of science and technology set up industrial research and consultancy centres. These centres act as a clearing-house for faculty consultancies, which are on a paid basis. Major interdisciplinary research projects are undertaken by several institutions acting in concert. Research institutes establish close links with industry, and some, like the Central Leather Research Institute, concentrate their efforts on a single industry, thereby developing specialist skills. Large, private-sector industries engage actively in co-operative research; and, as a result of deliberate government policy, the public-sector enterprises are now also active in this sphere. Fiscal policy provides incentives, for the Government allows a 133 per cent write-off for financing specific research projects.

Involvement

As already mentioned, mutual self-interest is the most powerful motivator of co-operation, which means that the university or research institute cannot adopt a high-handed, superior stance towards the client. One of the strengths of the Stanford Research Institute, for example, is that it tackles client-oriented, tangible problems, so that the results of the work are important for both the reputation of the Institute and the satisfaction of the client. The full cost is borne by the client, who expects to get value for his money. Since the future of the Institute depends on its earnings, it has a powerful incentive to do a good job. Thus, both the Institute and the client are "stakeholders in the project, and both co-operate to attain mutually desired ends." [11/]

10/ See Part two, chapter XV.

11/ See Part two, chapter VIII, p 43.

It may be, of course, that in many less developed countries, industry cannot afford to pay the full cost of research. Consequently, if indigenous industrial research is to be developed, government research establishments must be subsidized. This should, however, be regarded as a temporary measure, every effort being made to place the institutes on a self-financing basis as soon as possible.[12] Only then is the mutual self-interest given the kind of financial dimension that seems to be important for successful co-operation.

Contract

The tangible expression of mutual financial interest is the contract, an extremely important element in effective co-operation. Without a contractual relationship between the provider and the user of research facilities, universities and research institutes can waste scarce resources on research that has little or no relevance to the real needs of the society. In Poland, the Technical University of Warsaw signs contracts with certain big industrial establishments.[13] These contracts specify obligations on both sides as to training and research. The University undertakes to do a specified amount of training and research, while the factory may finance the purchase of equipment, provide laboratories and organize practical training for students.

In Yugoslavia, the Hasan Brkić Metallurgical Institute[14] has put its relations with industry firmly on a contract basis. Each project has a separate contract, stipulating the obligations of both partners. The Institute is required to provide the research and development service agreed upon, the solution being the subject of acceptance by a group of experts nominated by the customer. Thus, the service is based on demand not on supply. The customer is obliged to pay for the service as agreed upon in the contract. If the result is subject to a patent, the relation between the two partners is mutually agreed and legally binding. Experience in Yugoslavia has proved the value of this contractual relationship, but there are some basic conditions for success. First, the industrial management has to be research-minded and to have confidence in the institute's capability. Secondly, the institute has to be oriented towards practical problems and aggressive in the marketing of its skills.

12/ See Part two, chapter III.

13/ See Part two, chapter XIV.

14/ See Part two, chapter IX.

Research

The concept of mutual self-interest is most tangibly expressed when research is undertaken by mixed teams drawn from the university or research institute on the one hand and from the industrial client on the other. The Hasan Brkić Institute employs this method in metallurgical research, which requires multidisciplinary teams working through several stages, i.e. laboratory, pilot plant and industrial experimentation. In these circumstances the Institute constitutes the working teams not only from its own staff, but also from the engineers and technologists drawn from the industry concerned. One of the advantages of this method is that it minimizes the problems of communication between researcher and practitioner. The way in which results of research are communicated is a very important element in the acceptance of new technologies and methods of work. Where technologists from the industry are involved in the research and the researchers are involved in the implementation, difficulties are minimized and mutual self-interest operates from start to finish.

Training

Universities and industry can co-operate, again on the basis of mutual self-interest, by jointly arranging for the practical training of university students of engineering, science, management and other industrially oriented subjects. In the Polish case already cited, the contracts between the Technical University of Warsaw and big industrial establishments include clauses providing for the training of the University's students in the co-operating establishments. The University has the advantage of being able to offer its undergraduates a better education, and industry has the advantage of being able to assess the students with a view to employing them after they have completed their studies.

A highly developed form of this co-operation in training is the "sandwich system", whereby students spend roughly half their time in the university and half in industry. In this way, academic education and industrial training are well integrated, and the result is a graduate who has not only had a sound technical preparation for industry, but who is also psychologically oriented and motivated towards a career in industry. This system deserves to be much more widely adopted in developing countries than it is at present.

It is a classic example of the operation of the principle of mutual self-interest.

Summary

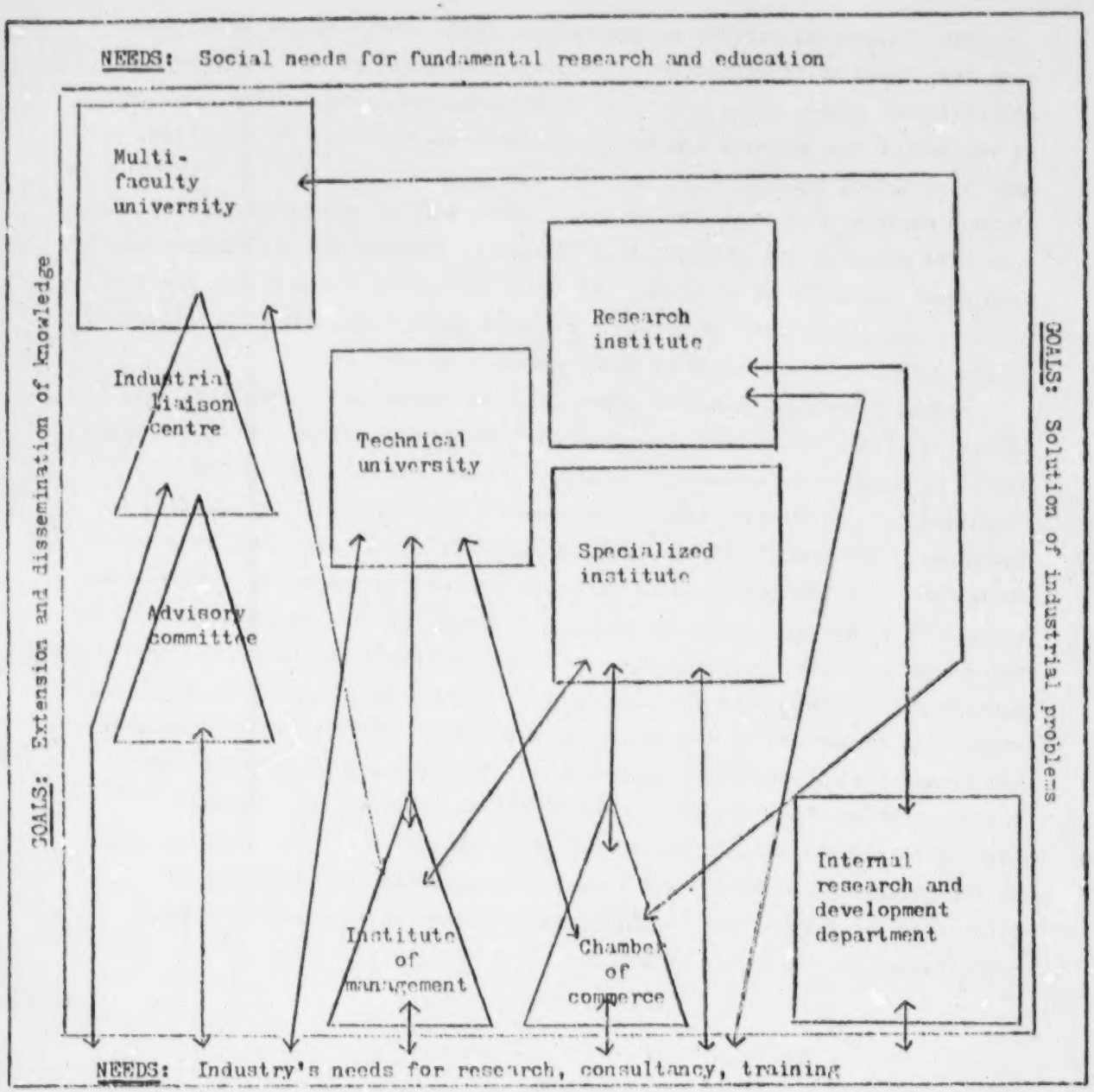
Only if all parties benefit will effective co-operation take place. Exhortations by governments, pleas by universities and complaints by industry are ineffective. Co-operation needs to be planned for by all the parties concerned, assisted by government, and resources made available for it to be implemented. But in the last analysis it is the mutual self-interest of the providers and users of research that will prompt actual co-operation as distinct from statements about its desirability. This usually means a clear financial incentive for the researchers and, in return, a willingness on their part to submit their work to the ultimate test of the market. It also means a positive attitude to research on the part of industry and a willingness to pay the market price for it rather than an expectation that it will be financed by the state.

IV. INSTITUTIONAL FORMS

The fundamental problem in identifying those institutional forms that have been found to be effective in promoting co-operation is to reconcile institutional goals, which may be, in varying degrees, congruent or incongruent. At one end of the spectrum are the traditional multifaculty universities, with many objectives, some of which are only very indirectly connected with the more obvious needs of industry, for example, the pursuit of knowledge for its own sake, the preservation of individual freedom of thought and the general non-vocational education of students. At the other end of the spectrum are the research and development departments of large enterprises whose objectives relate directly to the needs of their parent organizations.

Between these two limiting cases fall the technical universities, the specialist institutions and the research institutes. Because of the varying degree of congruence between the goals of these institutions and the requirements of industry, there is a need for some facilitating units at the interface - industrial liaison centres, advisory committees, institutes of management, professional associations and chambers of commerce. A figure can be used to illustrate two relationships of these interfacing agencies. At the top and on the left, respectively, the needs and goals most directly met by the multifaculty universities are indicated. At the bottom and on the right are indicated, respectively, the needs and goals most directly met by industry's own research and development departments. On the diagonal from top left to bottom right in square boxes are the technical universities, research institutes and specialized institutes that fall between these limiting cases. In the triangular boxes are the interfacing agencies and the linkages (indicated by arrows) that enable them to relate appropriately to these conflicting sets of needs and goals.

Model illustrating the role of interfacing agencies
in effecting co-operation among industry,
universities and research institutes



Industrial liaison centres

In the United Kingdom of Great Britain and Northern Ireland, university-industry co-operation is promoted through various types of interfacing units.15/ These are usually an integral part of the parent university, although they may be incorporated as limited companies. They attempt to identify (a) industrial needs and (b) relevant university resources and to relate each to the other. The resulting activities vary greatly - research under contract, consulting, licensing arrangements, patents, student projects and many others.

Because of the innate conservatism of traditional universities, the establishment of these centres needed some external stimulus, which was provided in the form of government finance for a limited pump-priming period of about three years, after which the centres were expected to become self-financing or financed from the general funds of the university.

By and large this has been a valuable development in industry-university co-operation. Of the 21 projects financed under the scheme, some of them research/or consultancy centres and some industrial liaison units, no fewer than 17 have been wholly successful. They have established strong links with industry, attracted income from research and consultancy contracts and generally enhanced the credibility of the universities in the business community and society at large. They represent a model worthy of adaptation to the needs of developing countries, especially as they can be started on a very small scale by appointing an industrial liaison officer. In fact, many of the British centres started in this way and grew as demand for their services increased.

Technical universities

Co-operation with industry and research institutes is easier for technical universities than for traditional multifaculty ones. Their goals are more congruent and their resources and expertise more obviously relevant. Moreover, whereas the status of the traditional university tends to be based on scholarship, that of the technical university is based on scholarship directly relevant to industry. Consequently, there is no difficulty in promoting staff who engage in industrial consultancy because it is very much part of the ethos of the technical university.

15/ See Part two, chapter I.

Graduates are readily adapted to industrial careers, and as they assume more influential positions they tend to enhance the standing of their university vis-à-vis industry. Technical universities find it easier to organise practical training for their students because of their rapport with industry, and this is particularly important with regard to the admirable sandwich course system. 16/

There is no doubt, therefore, that the technical university is a useful model for developing countries to consider. 17/ However, in view of the greater difficulty of staffing in technological subjects than in the humanities, some international assistance may be necessary. In obtaining this assistance, the establishment of links between technical universities in industrialized and developing countries can be beneficial.

Advisory committees

One way of influencing the university to adopt a policy of meeting industrial needs is to establish an industrial advisory committee, or a joint university-industry board. The latter might, as the name suggests, have rather more than purely advisory powers; it could, for instance, control the use of finance raised from industry for specific purposes related to university-industry co-operation.

Lack of adequate channels of communication often inhibits such co-operation, and these committees or boards, meeting regularly, provide a forum for a continuing dialogue between university, industry and the research institutes. In this way, attitudes can be changed, prejudices reduced, and mutual confidence engendered, which may in turn lead to the establishment of more active bodies such as the industrial liaison centres.

16/ See Part two, chapter XIV for the Polish experience.

17/ See Part two, chapter XVII for the Yugoslav experience.

Specialized institutes

Where, as in India, [18] the universities find it difficult to co-operate with industry, specialized institutes may be set up; the Indian Institutes of Technology and the Institutes of Management are good examples. Like the technical universities, these institutes are tertiary-level institutions, with high standards of research and teaching, but with a definite industrial orientation. Faculty are often interchanged with industry, undertake paid consultancy and do applied research with a clear industrial objective. Thus, these institutes face no great conflict in goals, and their standing depends largely upon their success in meeting real industrial needs.

It is, however, essential that they be staffed by faculty who are at least as well qualified - though, perhaps, in a different way - as their university counterparts. Staffing clearly poses a problem for developing countries, where there is usually an extreme shortage of scientific and technologically trained staff, so that international assistance may be necessary, e.g. through linkages with established institutes, either in experienced developing countries such as India or in industrialized countries.

Management institutes

Some developing countries such as India, Indonesia, Kenya, Malaysia and Nigeria have found that a useful interfacing unit between industry and university is the management institute, association or foundation. It consists of a voluntary association of business enterprises from both public and private sectors employing a small professional cadre of trainers and consultants to service member companies. It often draws also on appropriate faculty members from the local universities who work for the institute on a part-time, fee basis. This procedure gives these faculty members a valuable contact with business and makes their university teaching more effective. It also links industry to the resources of the universities and can lead to valuable research and consultancy contracts. Sometimes government subsidies are provided, but usually the principle of mutual self-interest applies, and the institutes are self-financing.

18/ See Part two, chapter XV.

Chambers of commerce and federations of industry

Throughout this report there has run the theme that real co-operation cannot be imposed, but must be voluntarily entered into on the basis of mutual self-interest.[19] Among the more important voluntary agencies in the business world are the chambers of commerce, trade associations and professional bodies. These can be valuable interfacing units between industry on the one hand and universities and research institutes on the other. Since membership is voluntary, policy is democratically decided, and any commitment to co-operation is likely to have the support of the majority of members - certainly the more progressive ones who have most to give and to gain from co-operation.

The School of Economics at Belgrade University signed a long-term agreement in 1971 with the local Chamber of Commerce. It provides for co-operation in organizing post-experience courses for practising managers; advice on curricula so as to relate them to the needs of industry; and facilities for students to gain industrial experience and for staff to undertake projects for Belgrade industries. The School of Economics now meets over 35 per cent of its financial needs from this and similar agreements.

The Stanford Research Institute has helped establish industrial research organizations in several developing countries, including Brazil, India, Peru and Singapore.[20] Co-operation with local organizations begins with the feasibility study, so that commitment to the project by those who are going to operate it is secured from the very start. The combination of professional experience from the technologically advanced Western world and intimate knowledge of the local environment and practices has been found to be effective in meeting the needs of industry and government in developing countries.

Summary

This chapter has done no more than mention some of the institutional forms of linkage that experience has shown to be effective. The digests of participants' papers given in part two describe them more fully. However, the need for flexibility, adaptation and experimentation remains, for each country has its own characteristics and must find its own solutions. In doing so, it can profit from the experience of others.

19/ See Part two, chapter XIII for the Ghanaian experience.

20/ See Part two, chapter VIII.

V. ROLE OF UNIDO

The three working groups produced many suggestions as to what UNIDO might usefully do to promote co-operation among industry, universities and research institutes. Most of these suggestions fell into one of three groups, namely, communication, innovation and evaluation.

Communication

There is often a lack of communication between the three parties; universities do not know the needs of industry, and industry is not sufficiently aware of the resources available in universities and research institutes. Hence, the fundamental problem exists of identifying needs and resources to meet them. Taken on a world-wide scale, this is an immense task and clearly beyond the capacity of any one international agency. Nevertheless, UNIDO could play an important role through its network of field advisers. They could feed appropriate information about needs and resources into a central, computerized data bank at UNIDO headquarters. These data could be made available to Governments as well as to United Nations agencies and officers.

International seminars, conferences and workshops could contribute to a wider and better understanding of the problem. Most meetings should, however, be concerned with specific topics and experience rather than with theoretical subjects. Since it appears that senior government officials as well as industrialists and academic leaders are often unaware of the importance and practicability of co-operation, UNIDO could usefully bring them together in an effort to persuade them of its advantages.

Faculty exchange programmes could also help to educate those who could influence others to adopt a more co-operative attitude. Probably it would often be necessary to exchange faculty from developing countries with faculty from industrialized ones because that is where most experience in co-operation is to be found. Wherever possible, however, exchanges between developing countries within a region should be encouraged in view of cultural, social, political and other differences.

A critical aspect of this training process is the equipping of existing or potential directors of research institutes and the various interfacing agencies to undertake their vitally important roles. Senior fellowships for this purpose could provided, administered and monitored by UNIDO.

Innovation

From time to time UNIDO has the opportunity to undertake a major project to initiate co-operation among industry, a university, and a research institute in a particular country as part of a Government's development programme. Now that the Lima Conference has decided that UNIDO should give priority to certain industries such as steel, chemicals, engineering and agro-based or related industries, it may be easier to organize such projects, since the task of matching resources to needs is somewhat simplified.

The Expert Group expressed the hope that UNIDO would, with the establishment of the Industrial Development Fund, be increasingly active in initiating projects designed to encourage co-operation, e.g. by helping to establish the appropriate interfacing agencies described in the previous chapter.

UNIDO already has gained valuable experience in doing that. For example, it assisted in establishing the Hasan Brkić Institute in Yugoslavia and the Marmara Institute in Turkey by providing fellowships, expert advice and equipment.[21/] The organization has also helped these two institutes to co-operate on a joint research project on quality control in iron and steel production. This project is jointly financed by UNIDO and the Turkish steel industry. In its turn, the Hasan Brkić Institute has provided, with UNIDO assistance, staff members to work on metallurgical research in Egypt and Turkey. Here, then, is a good example of the innovative role that UNIDO can play in establishing not just research institutes as such but also means of collaborating to the benefit of more than one developing country.

Evaluation

Throughout this report emphasis has been placed upon the need for experimentation and for each country to evolve a system of co-operation that is relevant to its own situation. However, if the maximum advantage is to be gained from experience, objective evaluation of that experience is required. Here is an important role for UNIDO. As an international organization, it is well placed to review the experience of collaboration in member countries and to pass on the results of that evaluation to others. It could, therefore, usefully conduct pilot surveys in, say, four respective developing countries to identify needs and to evaluate the degree to which

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21/ See Part two, chapter IX.

they have been met by the machinery for collaboration that exists in those countries.

It was the view of the Expert Group that UNIDO should give special attention to identifying successful experience of collaboration in industrial research and to promoting similar developments in other countries. Universities, research institutes and representative industrial organizations could all provide UNIDO with data on their experience of co-operation, whether positive or negative, and some would be willing to provide resources to stimulate co-operative ventures in other countries. Examples of the kind of resources that the Expert Group Meeting suggested might be provided are the following:

Advice on formulating research policy, managing research and development, selecting research methodology and establishing research institutions

Provision of research facilities to supplement those of relatively underdeveloped institutions

Assistance in establishing new industries on a joint-venture basis, including internal research and development departments where appropriate

Provision of training for scientists, research managers and university students

Establishment of links between well-developed institutions and those requiring assistance

Exchange of information, publications and "know-how"

Recruitment of experts for UNIDO projects

Encouraged by the willingness of participants to help in ways such as these, the Expert Group Meeting agreed that UNIDO should undertake a survey designed to identify the resources available to promote co-operation in research and development. These resources could then be matched with needs as they became known, UNIDO acting as the facilitating agency in whatever manner might be appropriate to each individual case.

Part two

DIGESTS OF PAPERS PRESENTED TO THE MEETING

I. THE ROLE OF INTERFACING UNITS BETWEEN UNITED KINGDOM UNIVERSITIES AND INDUSTRY

R.V. Arnfield

The watershed year for increased collaboration between universities and industry in the United Kingdom was 1965, when a conference on the subject was organized by the Confederation of British Industry and the Committee of Vice-Chancellors and Principals. The conference was followed by the establishment of a joint committee of academics and industrialists and a report was published on the relationship between universities and industrial research.

In 1967, the University Grants Committee, which is the major source of university funding, set aside two million pounds to pump-prime industry-oriented ventures proposed by universities, with the intention that these should either become self-supporting or financed from general university funds.

Although many innovations flowed from this initiative, perhaps the most important was the establishment of a large number of interfacing units designed to bridge the gap between the goals, needs and attitudes of universities and industry.

Many of these units started from a small and simple base, i.e. the appointment of an industrial liaison officer exercising a broad catalytic role at the interface between universities and industry. Other universities set up centres for industrial consultancy and liaison to negotiate consultancy and contract research, and to establish contacts with industry which would generate additional income. Several universities have created companies required to operate on a business basis.

The consensus is that these experiments have on the whole been successful and worthy of study by universities in developing countries.

II. THE MARKET RESEARCH CONTRIBUTION TO THE INDUSTRIALIZATION OF DEVELOPING COUNTRIES

F.D. Barnard

The key role of market research in assisting the industrialization of developing countries is to help ensure that industrial research, technical assistance and direct foreign investment shall be applied most effectively - through an understanding of the characteristics of the market concerned. This leads to industrialization projects that create the products and services best designed to meet the real needs of the population, with benefits that include:

Raising the standards of living, nutrition and health

Providing secure employment in the industry concerned (whether through national or multinational organizations or any of the various forms of joint venture)

Import substitution and export earnings potential

Furthermore, the application of market research in developing countries provides opportunities for training local staff and the transfer to them of skills and knowledge in market research and other marketing-related disciplines. The acquisition of such skills adds to the reservoir of management resources in those countries.

As developing economies grow, the tastes and behaviour of the population change (as do those of the industrial organizations that serve them). These processes must be monitored and acted upon if the industrial system is to adapt to these trends and to provide the goods and services appropriate both to the needs of the local population and to export markets. Hence, the establishment of a healthy local market research industry is an integral part of successful industrialization.

III. STUDY OF THE RELATIONS BETWEEN INDUSTRY AND OFFICIAL RESEARCH CENTRES - A SPANISH CONTRIBUTION

J. Cordero and V. Reig

Spain has evolved a number of institutions designed to promote co-operation among industry, universities and research institutes. Among these are the following:

(a) The Superior Board for Scientific Research is an organization of the Ministry of Education and Science which co-ordinates the research institutes dependent on it;

(b) A Registry of Contracts for the Transfer of Technology has been created within the Ministry of Industry to assess the availability of foreign technology, regulate its acquisition and promote its adaptation to local needs;

(c) The Scientific and Technical Research Advisory Commission has been established to promote research by making finance available, formulating research plans and founding research associations. The research plans consist of contracts with companies whereby the Advisory Commission grants the company a loan of up to 50 per cent of the total estimate, with favourable terms of reimbursement. Approved programmes are supervised by Executive Commissions of the Advisory Commission. These Executive Commissions keep in close touch with the companies during the period of the research programme. As a result, a useful relationship builds up between industry and the research centres, and it may lead to research contracts on other subjects. The Advisory Commission promotes the creation of research associations by bringing together companies with similar needs, developing work programmes and establishing co-operative research centres. The Commission subsidizes these associations by up to 50 per cent in the early years, tapering off as income builds up;

(d) The University-Company Foundation has recently been sponsored by the Madrid Chamber of Commerce to promote co-operation between industry and research institutions, sponsor research projects and publish results.

Experience of promoting co-operation between industry and research institutions in Spain would suggest that industry should be involved from the start; temporary subsidies may be required, and the sharing of risks greatly strengthens the relationship.

IV. UNIVERSITY-INDUSTRIAL RESEARCH ORGANIZATION - INDUSTRY CO-OPERATION : THE CASE OF NIGERIA, WITH EMPHASIS ON THE UNIVERSITY OF LAGOS

H. Enahoro

Universities, colleges of technology, polytechnics and industrial research organizations play a key role in the industrialization of developing countries. However, they are often relatively new, and faculties of engineering may be the last to be established. Another problem is that policy in the multifaculty university may be largely decided by those whose academic interests are not very closely related to industry.

Nevertheless, the Faculty of Engineering of the University of Lagos is involved with industry, providing consulting and testing services. The Faculty was started by UNESCO, and its laboratory facilities are increasingly being made available to industry. The Federal Institute of Industrial Research is situated at Lagos and co-operates actively with the university by having academic members on its management board.

The Nigerian universities feel that the best way of serving industry is to produce a steady supply of highly qualified engineers. This involves practical as well as theoretical training and for this purpose the University of Lagos proposes to build an industrial centre which will be a factory complex in which each engineering student will spend six months of his four-year course. One of the largest sections in the centre will be the research and development section, and it is hoped that it will be extensively used by both public and private sectors of industry.

The Nigerian Government has set up an industrial training fund whose purpose is to reimburse firms for what they pay students who are receiving practical training with them during the long vacations. This brings industry and university together with some financial incentive. Supporting this move towards co-operation is the appointment of an industrial relations officer in the Faculty of Engineering. His main functions are to place students in industry during vacations, to monitor such training and to serve as a link between the Faculty and industry.

V. THE LINK BETWEEN INDUSTRY, UNIVERSITIES AND RESEARCH INSTITUTES, WITH SPECIAL REFERENCE TO THE EGYPTIAN EXPERIENCE

F. Garrana

Egyptian universities have not been particularly active in industrial research, and Egyptian industry has relied mainly on imported technology. The Egyptian National Research Centre has been established to be the link between research and the economy in general, but it has not realized this goal because of poor contacts with industry, a promotion policy based on traditional academic research, lack of staff experienced in industrial research and bureaucratic control.

This problem has been examined by a series of committees. Factors promoting more successful co-operation seem to be a greater awareness by management of the importance of industrial research; the provision of financial incentives and better promotion prospects for staff undertaking industrial research; the establishment of research departments within industry; the appointment of research consultants to industry from the research institutes; and joint attempts to adapt imported technology to local conditions.

UNIDO can play an important role in developing links between industry, universities and research institutes by encouraging the exchange of information about measures that have proved successful in promoting co-operation and providing the experts and equipment necessary for the successful development of joint industrial research in some developing countries.

VI. PAST AND CURRENT UNESCO ACTIVITIES IN EDUCATION-INDUSTRY CO-OPERATION

A. Goodyear

Since its creation in 1946, UNESCO has been concerned with the application of science to development, but education-industry collaboration began to receive special priority around 1960. Assistance programmes have included many institution-building projects, helping member States to create or strengthen institutions for training scientists, engineers, technicians and technical teachers.

UNESCO has organized a wide range of regional meetings concerning research priorities and the promotion of regional co-operation in research. UNESCO has also provided support to many regional or international research centres. Since 1970, education-industry co-operation has been one of the priority areas for UNESCO programme activities in engineering education, and many papers are available from the Division of Technological Research and Higher Education, UNESCO, some of which contain interesting examples of co-operation in developing countries, worthy of wider discussion in other countries where similar problems exist.

Education-industry co-operation is one of those areas in which more than one United Nations agency has a proper interest. Thus there is need for continuous consultation through interagency agreements and intersecretariat consultative mechanisms such as already exist between UNIDO and UNESCO. In addition, where UNIDO field projects exist in industry in the same countries as UNESCO projects in universities, attempts should be made to develop pilot examples of co-operation in specific fields. In developing countries where industries are being established with UNIDO guidance, co-operation with UNESCO and the International Labour Organisation may prove beneficial, especially for planning university and other education and training programmes.

VII. CO-OPERATION BETWEEN RESEARCH INSTITUTES FROM DEVELOPING COUNTRIES AND SIMILAR INSTITUTIONS FROM INDUSTRIALIZED COUNTRIES AGAINST THE BACKGROUND OF MATERIALS RESEARCH AT MARMARA SCIENTIFIC AND INDUSTRIAL RESEARCH INSTITUTE

D. Gücer

The Scientific and Technical Research Council of Turkey, which is connected with the Office of the Prime Minister, was founded in 1963 to develop, promote, organize and co-ordinate fundamental and applied research in science and engineering. In 1966 it was decided to establish an industrial research institute, which came to be known as the Marmara Scientific and Industrial Research Institute.

The Institute started in 1968 with the organization of several research teams at Turkish universities, the objective being to accumulate experience before the Institute itself became operational. The Institute was built in a growing industrial area near the town of Gebze, which made contact with industry easy. It undertakes research on materials, electronics, applied mathematics, industrial chemistry, operations research, food technology and nutrition, each of which has a separate research unit. Two other units are being started, in mechanical engineering and applied physics.

The Materials Research Division at Marmara started in 1968 with the appointment of a director; today it has a staff of 50, of whom 24 are scientists. The Division's research programme consists of 10 per cent basic research, 20 per cent applied research and 70 per cent development research, trouble-shooting, tests, analyses etc. It has been receiving technical assistance from UNIDO since 1974 in the form of equipment, expert advice and training.

An important development in international co-operation has been the relationship between the Materials Research Division at Marmara and the Metallurgical Institute Hasan Brkić in Yugoslavia. Marmara untertook a co-operative project for the development of quality and process control systems in a major Turkish steel plant, selected as most important from the standpoint of its impact on the industrial development of the country. Provision was made for subcontracting part of the work to Hasan Brkić and,

since Marmara could not pay for it, UNIDO provided the necessary funds.

The Marmara experience illustrates the valuable role that UNIDO can play not only by providing equipment, experts and training for setting up a new institute, but also by facilitating co-operation between institutes in developing countries to their mutual advantage.

VIII. CO-OPERATIVE EFFORTS FOR INDUSTRIAL DEVELOPMENT: APPLICABLE ASPECTS OF THE STANFORD RESEARCH INSTITUTE EXPERIENCE

W.F. Harwood

The Stanford Research Institute's business consists of solving problems for industry and government on a contract basis, and it operates on an international scale. It was created 30 years ago by Stanford University in California, which had seen the need for university-industry linkage via research and consulting services to the mutual advantage of both parties.

Formal ties between SRI and Stanford University were severed in 1970, but close professional co-operation continues, which permits the University to concentrate more on academic research and SRI on solving practical problems. An essential feature of all SRI projects is that their outcome is important to both the institute and the client. As a result, both are stakeholders in the project, and both co-operate to attain mutually desired ends.

Over the years, SRI has helped establish research institutes in many countries such as Brazil, India, Japan, Lebanon, Peru and Singapore. It also conducts joint studies with overseas institutes, which are valuable in the training they give to local staff. A good example was an inquiry on the costs of urban infrastructure in India, undertaken jointly by SRI, the New Delhi School of Planning and the Small Industry Extension Training Institute, Hyderabad. It showed the value of exchanges between public agencies and industrial investors and the need for better funding of interprofessional collaboration.

SRI has been a member of the World Association of Industrial and Technological Research Organizations (WAITRO) since its inception in 1970 and takes an active part in its affairs. It is felt that WAITRO can make a valuable contribution to developing country institutions by the exchange of experience of research and research management.

The Institute believes that emphasis should be placed on modernization rather than just industrialization, economically and socially efficient technology rather than advanced technology, technology compatible with that of the industrialized countries, a multidisciplinary approach to problem solving, and more joint collaboration between organizations in the Western and third worlds.

IX. METALLURGICAL INSTITUTE HASAN BRKIĆ ZENICA, A CASE STUDY OF CO-OPERATION WITH INDUSTRY

K. Kapetanović

The Metallurgical Institute Hasan Brkić Zenica was founded in 1961 to meet the research and development needs of Yugoslavia's steel industry. It was decided to locate the Institute in Zenica, since it is the centre of the country's steel industry, thus making every-day contact easier. It concentrates on four categories of research: (a) process research;(b) product research; (c) metallurgical engineering studies; and (d) fundamental research. It seemed unrealistic for a country like Yugoslavia to try to develop completely new processes, and it was felt that the aim should be rather to adapt technology transferred from developed countries. Similarly, product research is related to the country's own needs in that its aim is to evolve a special product mix which attracts higher prices and contributes more to the national economoy. Metallurgical engineering studies are confined to local problems, and care is taken to ensure that fundamental research shall be limited to what is within the human and economic resources of the country.

From the start the Institute has established relationships with industry on a contract basis,whereby the obligations of both parties are stipulated. To establish this essentially businesslike relationship, two conditions are needed, i.e. a research-minded industrial management and confidence in the institute's capability. For this reason, attention has to be paid to appointing researchers with industrial experience, for they are better able to bridge the gap between the research institute and industry. Also, the institute has to be market-oriented and willing to adopt an aggressive marketing policy. Hasan Brkić has made a point of constituting working research teams not only from different disciplines, but also from industry and university as well as from its own staff. This ensures a degree of commitment to implementing the research results and helps to bridge the communications gap.

The Institute seeks to co-operate with similar organizations in other developing countries and has a joint project with the Marmara Research Institute in Turkey[22/] and the Central Metallurgical Research and Development

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22/ See Part two, chapter VII.

Institute in Egypt. The latter is concerned with the improvement of the quality of ingot moulds - a major problem in the Egyptian steel industry.

Hasan Birkić owes much to UNIDO, for it provided fellowships, experts and equipment in the first stage and, later on, staff members for the Turkish and Egyptian collaborative projects.

X. CO-OPERATION AMONG UNIVERSITIES, INDUSTRIAL RESEARCH ORGANIZATIONS AND THE ROLE OF UNIDO IN THIS CO-OPERATION

T.A. Khan

In the years following Pakistan's independence, industry relied largely on imported technology, and the universities were concerned with academic teaching divorced from production. Now, steps are being taken to make education serve socio-economic objectives. Priority is being given to the creation of research facilities in universities, and government policy is that this research should be goal-oriented rather than fundamental.

In addition there are institutions providing consulting services, such as the Pakistan Industrial Technical Assistance Centre, which upgrades skills, produces new designs of equipment, and gives technical advice to industry.

The Cotton Textile Industry Research and Development Centre was set up in 1973 to assist the largest private-sector industry of Pakistan. So far, 11 UNIDO experts have joined the Centre, which concerns itself with textile technology, industrial engineering, product development, textile chemistry, applied research and instrumentation.

The largest industrial research organization in the country is the Pakistan Council of Scientific and Industrial Research (PCSIR). Among its staff of 2,000 are some 900 scientists, many of whom have been trained in industrialized countires. The Council's task is to promote scientific effort, largely by establishing national laboratories and institutes at Karachi, Lahore and Peshawar. Laboratory research is converted into industrially feasible projects through pilot plant investigations to successful commercial enterprises.

The Federation of Pakistan Chambers of Commerce and Industry has encouraged close collaboration between the scientific staff of PCSIR and industry. In functional committees scientists and industrialists discuss together research needs and research results, which leads to better understanding on both sides.

Government policy is that industry should earmark 1 per cent of its turnover for the support of research and development. Vigorous efforts are also being made to forge closer links between universities and industrial research organizations. Some of the PCSIR laboratories are located close to universities to facilitate the exchange of scientific staff.

XI. RESEARCH-INDUSTRY LINKAGES - THE EXPERIENCE IN TURKEY

R.D. Lalkaka

At present, Turkish manufacturing enterprises, both State and private, do practically no in-house research, and the technologies employed are often inappropriate or out of date. However, the Fourth National Development Plan is expected to lay stress on science and technology, and UNIDO has been involved in the establishment of new research centres.

The first step - and one often missed - is to survey needs before the decision is taken to set up an institute. For example, in starting the Materials Research Unit at the Marmara Scientific and Industrial Research Institute, a UNIDO consultant was engaged to make a survey of research requirements to ensure that the facilities and programmes were demand-based and not supply-oriented.

The ideal situation is where a sponsor pays for the research, which is thus subjected to the test of the market. But in most developing countries research services are expected to be supplied "free" to taxpayers. Undoubtedly the best motivation is the personal involvement of the end-user in the research task. This principle has been followed in several UNIDO projects in Turkey such as the Marmara Research Institute, the Cement Research and Development Centre, the Textile Training and Research Centre, and the Leather Research and Training Institute. The latter three all combine training and research under one roof, thereby facilitating interaction between the two functions and ensuring that research shall be transferred into practice via training.

The Marmara project is the first in Turkey to have a national as UNIDO project co-ordinator, who is also a professor at the Istanbul Technical University, thus strengthening university-research-institute-industry linkage. The Textile Research Centre is establishing an advisory board to increase participation by private industry. This method has been found to work well at the Leather Research Institute, which serves numerous small, scattered footwear workshops, each with a small output. The participation of the Chambers of Commerce and Industry has been particularly helpful here.

It has been found that the technical assistance requirements of countries at the development level of Turkey call for a departure from conventional patterns and the adoption of innovative forms - a challenge which UNIDO has been able to meet successfully.

XII. THE APPLICATION OF SCIENCE IN POLISH INDUSTRY

R. Maj

In Poland, theory is closely linked to practice and the efforts of workers in both scientific and economic fields are combined to attain the best results in the realization of production targets. Scientific research is conducted in four groups of institutions: (a) the Polish Academy of Sciences; (b) college institutes, polytechnics, universities; (c) government research institutes; and (d) industrial research centres. Typically it is the institutions in the third and fourth groups which work for the benefit of industry, but they frequently co-operate with other groups.

The organization of research in Poland can be illustrated by reference to the Sea Fisheries Institute in Gdynia, which has operated for 55 years and employs 700 persons, of whom 300 are scientists. Any research idea put up by an enterprise, industry or ministry is examined and, if accepted, is embodied in a contract which sets out the objects, states the budget and describes the operational arrangements and mutual obligations.

Research activities range from routine laboratory studies through licensing arrangements to long-term research projects for a whole industry. Large enterprises may have their own research institutes and information centres, but they work together to form a nationwide information system.

Bilateral contacts between scientists in enterprises and experts from industry in the Institute enable regular exchanges of ideas. The managers of the Institute meet regularly with the directors of the enterprises to ensure co-operation and dissemination of research results. An example of this successful joint research was the discovery by the Institute's research vessels of rich fishing grounds, which were then exploited by the Polish fishing fleet, enabling the entire cost of the research to be covered for several years.

XIII. CO-OPERATION AMONG UNIVERSITIES, INDUSTRIAL RESEARCH ORGANIZATIONS AND INDUSTRIES IN GHANA

E. A. Ocloo

Before Ghana attained its independence in 1957, there was only one university and one research institute, and most of the industries were either privately owned foreign ones or transnationals, depending on the overseas parent company for their research. Now there are about 450 members of the Ghana Manufacturers Association, of which the indigenous members comprise about one third. Since most of these have very limited education, communication between them and the research scientists is difficult. Frequently the educated scientist tends to look down on the less well-educated business man, and there may even be open confrontation.

The Ghana Manufacturers Association is now playing an important part in promoting co-operation between the two parties so as to improve the position of indigenour manufacturers. The Association corporately and its members individually are establishing valuable contacts with universities and research institutes. The Kumasi University of Science and Technology is setting up a Consultancy Centre; and the Ghana Manufacturers Association, in collaboration with the Government, has established its own technical unit for industrial training and consultancy.

The experience gained in Ghana shows how important can be the contribution made by manufacturers associations and chambers of commerce as interfacing units, helping to bridge the attitudinal and communications gaps which so often exist between science and industry. The voluntary nature of their membership is a source of strength, as is also their independence from government control. Their co-operation is firmly based on mutual self-interest, but is directed towards the larger interests of the country and its peoples.

XIV. CO-OPERATION BETWEEN UNIVERSITIES AND INDUSTRY

Z. Osinski

In pursuing university-industry co-operation, technical universities are in an advantageous position. They provide the national economy with engineers who are easily absorbed into industrial establishments. Secondly, their research policy is industrially oriented, so that goals in teaching or research do not conflict. Students receive practical training alongside their academic work and are often taught by part-time lecturers from industry and by full-time academic staff. Faculty members are usually active in consultancy and engaged in applied research in joint teams which include scientists from industry as well as from university. They may also engage in joint research teams with colleagues from industrial research institutes.

A good example of all this is provided by the Warsaw Technical University, which signs general agreements on co-operation with big industrial establishments. These agreements stipulate obligations on both sides as to training and research. The University is bound to give training to a definite number of trainees from industries, to exchange staff and to engage in agreed research programmes. The industrial concern often finances the purchase of equipment, guarantees laboratory space, and organizes students' practical training.

Emphasis is placed on continuing education, with the provision of evening and extra-mural courses, leading to degrees. The sandwich course system is also used, whereby students alternate between six months in the University and six months in the factory.

The University actively co-operates with industry in research, on the basis of an agreed five-year plan, confirmed by the State Commission for Planning. It is recognized that there may be a natural conflict between the creative individuality of scientists and the demands of the plan, and efforts are made to meet the needs of both sides. Where extra duties are required, extra payment is made, which is used to offer financial rewards to scientists and also to provide a fund for the purchase of additional equipment.

Thus, the different but complementary interests of scientists, the University, industry and the State are recognized by all sides.

XV. CO-OPERATION AMONG INDUSTRIES, UNIVERSITIES AND INDUSTRIAL RESEARCH ORGANIZATIONS, AND THE ROLE OF UNIDO

S. Paul

The university-industry research system in India consists of four distinct categories of institutions: (a) universities, which are primarily teaching institutions; (b) specialized institutes for science, technology and management, concerned with both teaching and research; (c) national laboratories for scientific and technological research and extension; and (d) all-India councils for planning and controlling institutions working in similar fields, such as the Council of Scientific and Industrial Research (CSIR).

In the Fifth Five-Year Plan (1974-1978), industry-university collaboration was specifically encouraged. A new Department of Science and Technology was charged with the responsibility of ensuring that research would be oriented to the user. The major institutes of science and technology have set up industrial research and consultancy centres to undertake assignments for industry. All staff consultancy is routed through these centres, and a ceiling is put on the maximum earnings faculty may receive from such projects. Major research projects are undertaken on a collaborative basis with several institutions participating. Use is made of visiting faculty from industry; students are given industrial training; and post-experience courses are provided for those already working in industry.

Among the specialized institutions with close linkages with industry are the Central Leather Research Institute, the Technical Teachers Training Institutes, the Institutes of Management and the Small Industry Extension Training Institute. At the other end of the scale are the 100 or more universities, which tend to be the weakest in respect of collaboration with industry. There are problems of attitudes and values, massive size and preoccupation with undergraduate teaching, which make collaboration difficult. However, national councils like CSIR are beginning to stimulate the interest of universities in industrial research.

As far as industry itself is concerned, it is the large, enlightened private concerns which have until recently been active in university-industry collaboration. With the growth of the public sector, it is now the giant, technologically intensive public-sector firms which are taking the lead.

The Government is backing the forward move by, for example, offering tax incentives, whereby there is a 133 per cent write-off for financing specific research projects. Many forces are, therefore, combining to increase university-industry collaboration in modern India.

XVI. CO-OPERATION BETWEEN INDUSTRY, RESEARCH INSTITUTES, UNIVERSITIES AND UNIDO, WITH REFERENCE TO THE EXPERIENCE OF THE INSTITUTE FOR INSTRUMENT DESIGN IN BULGARIA

K. Popov

During the past five years, the Bulgarian Government has continued its policy of rapid industrialization, 85 per cent of the total production of the country being industrial. It is envisaged that 35 per cent of capital investment should be allocated for the implementation of new technologies and for the modernization of productive processes.

In 1966, with UNDP assistance, the Institute for Instrument Design was established with the objectives of developing automation, increasing productivity, improving quality control, training production personnel, and studying the future industrialization needs of the country. These are closely interrelated objectives. Experience has shown that not only is the development process important, but also the implementation, which inevitably involves close interaction with industry, for example, by training staff in the new technologies.

Over time, many of the technical staff in the Institute moved into the factories to implement the new ideas, which led the Institute to establish contacts with the universities as sources of innovation. Since this co-operation was on a contract basis, many academics became interested in developing prototypes, which were taken back to the Institute to be adapted for plant production. In this way an interactive system evolved between industry, university and research institute.

As for incentives, scientists are paid extra for work that they do on industrial contracts; furthermore, one of the criteria for promotion is success in implementing research results in production. In this way, self-interest is recognized and reconciled with the needs of society for greater productivity.

XVII. THE NEED FOR LONG-TERM CO-OPERATION AMONG THE UNIVERSITIES, RESEARCH ORGANIZATIONS AND INDUSTRIES IN DEVELOPING COUNTRIES

S. Ristić

Social, economic and technological progress implies a high interdependence of individual social sectors. In spite of the tendency of certain sectors to retain a high degree of independence, only through mutual co-operation can the best use of scarce resources be secured, particularly since technology has outstripped planning, design and production and has created an urgent need for applied research. Developing countries must to a large extent co-operate with each other so as to avoid "technological colonialism". They should not simply follow the practices of industrialized countries, but work out their own strategies for achieving economic and technological prosperity.

Thus, research and educational institutions should be oriented towards real problems of industrial development and imported technology adapted through appropriate local research. Most developing countries, faced with an acute shortage of indigenous scientists, concentrate industrial research in independent research institutes. There is need, however, gradually to create research and development capacity within large industrial enterprises, to bring research and implementation as close together as possible, as in industrialized countries, where two thirds of research capacity is within industry itself. In this way the excessively academic orientation of universities and research institutes and the inhibitions of control by government bureaucrats can be avoided.

Since World War II, Yugoslavia has industrialized substantially. Whereas in the earlier years industrial research tended to be concentrated in the 300 or so research institutes, today most large industrial enterprises have their own research and development laboratories employing about one third of the country's research workers. Universities, too, have been linked to industry, which is increasingly participating even in their financing.

Self-management agreements, clearly defining contractually the rights and obligations of the participating parties, are becoming more common. For example, the School of Electrical Engineering of the Sarajevo University has a co-operative agreement with Energoinvest, one of the biggest electrical engineering enterprises in Yugoslavia. It includes financial assistance for buildings and equipment, computer facilities, curricular advice etc. In return, the University is committed to meeting specified needs of the enterprise for research training.

XVIII. INDUSTRIAL RESEARCH AND DEVELOPMENT, SOME ASPECTS OF THE NORWEGIAN EXPERIENCE

T.K. Roderburg

Norway is a small country with a population of only 4 million. Ten per cent of the working population is employed in agriculture, forestry and fisheries, and 40 per cent in industry; there has been a gradual shift of the working population out of agriculture into industry and the service trades. Most industrial firms are small, three quarters of them having fewer than 20 employees. The population density is low, and government policy favours industrial dispersal away from the urban centres.

In 1974, Norway used 1.3 per cent of the gross domestic product for research and development. Financing was two thirds government and one third industry. About 44 per cent of expenditure on research was in the business sector, both public and private, some two thirds being in industrial firms and one third in research institutes. There are three types of research institute: (a) institutes serving a particular industry; (b) institutes working within a particular scientific area, e.g. geotechnical research; and (c) multidisciplinary contract research institutes.

One of these is the Central Institute for Industrial Research, with a staff of 320 and a budget of $10 million. Activities fall into three categories: (a) contracts with industrial and other clients (55 per cent of income); (b) research council projects (25 per cent of income); and (c) the Institute-controlled programme of pilot projects, staff training and information, for which the Institute receives a grant amounting to 20 per cent of total income.

The fact that income to a large extent depends on the Institute's ability to satisfy its clients is a powerful incentive to respond readily to the ever-changing needs of industry. Very close contact with industry is required, and the most efficient type of contract is that which evolves through co-operation with a client on specific projects. The best sales promotion is a successfully completed project. Although there is much repeat business, active marketing of the Institute's services is needed, which implies close contact with industry.

The University of Oslo is a close neighbour, but there is practically no co-operation on project work because the tradition is more academic than industrial. By contrast, the research institute in Trondheim was created by the university there and operates on campus with professors active on project work.

Norwegian experience underlines the importance of paid contract research as the prime motivator of real co-operation. Secondly, co-operation with universities is easier if they are engaged in teaching technological subjects and are located near the research institute.

XIX. THE CONSUMER MOVEMENT AND INDUSTRIAL DEVELOPMENT

P. Sand

The International Organization of Consumer Unions links consumer organizations all over the world. These organizations assist the transfer of technology to developing countries, foster the development of national standards, identify consumer needs, and bring pressure on governments and industry to improve standards and quality.

Most consumer organizations work closely with the government, university and independant research establishments in developing and executing their testing and research programmes. In this they promote co-operation and research directly related to consumer needs.

Without demand from consumers, retailers and manufacturers for satisfactory goods and services, there is a risk that unsuitable, unsafe or unreliable goods will flood the market. Consumer organizations, by virtue of their testing, reporting and consumer education, play a part in promoting economic development.

Consumer organizations are in a unique position to draw on technical help from universities and research establishments. By focusing the attention of scientists on practical problems and involving them in their negotiations with manufacturers, the consumer organizations help bridge the gap between scientific institutions and industry, and between industry and the consumer.

XX. CO-OPERATION AMONG UNIVERSITIES, INDUSTRIAL RESEARCH ORGANIZATIONS AND INDUSTRIES IN TURKEY

T.G. Uras

It is well known that scarcity and wastage of existing resources are the two most important problems faced by developing countries. To neglect scientific data and depend solely on traditional forms of production is to waste resources Thus, co-operation between institutions providing new knowledge and industry that can use it to the national advantage is essential.

Turkey has serious problems in this regard. Industrial research in its universities is generally inadequate and does not meet existing needs. Industry generally does not feel the necessity for co-operating with universities, and some of the larger enterprises have set up their own research units. Others buy research from foreign countries. Because industrial enterprises seem often to be unable to define their research needs, industrial research establishments and universities carry out their activities not according to demands put on them by industry, but according to what they see as the real needs.

The pattern is, therefore, a rather unco-ordinated one. Technical trade schools and universities provide industrial training and research. There are also public and private research institutes, commercial bureaux and individual consultants, and the State encourages small and medium-scale industry to use their facilities. Large-scale industry encourages their development and puts pressure on universities to do more industrial research and to adapt their educational programmes to industrial needs. Despite the unstructured nature of the Turkish system of industrial research, significant progress has been made.

XXI. HOW CONTACTS BETWEEN RESEARCHERS IN UNIVERSITIES, RESEARCH CENTRES AND INDUSTRY CAN BE STRENGTHENED IN THE INTERESTS OF THE THIRD WORLD

B. Zimmerman

In co-operation in research, the essential need is for personal contacts. One individual can never know all the experts in universities and research institutes who might be able to help him with his particular industrial problem. The same is true of individual countries. How, then, can we know where to find a suitable partner with whom to co-operate? There is only one way - to ask a host of experts in organizations, firms, libraries, universities, until the right partner is found. It sounds complicated but can usually be done quickly enough.

Some years ago there were extensive but fruitless discussions with computer producers and a United Nations organization about establishing an information storage and retrieval system to solve this problem. It was not, however, a feasible project because changes take place so quickly that any such information store would be quickly out of date. Moreover, the system would inevitably become an inefficient, inflexible bureaucracy.

UNIDO should, instead, concentrate on promoting meetings in Vienna and in as many other places as possible to provide contacts, stimulation and exchange of knowledge. In this way it will best inspire researchers, scientists, experts, practical people and politicians to become active in the pursuit of the goals of UNIDO.

VOEST-Alpine has transmitted knowledge for many years by letting the personnel of other firms work alongside its own staff until they grasp what is going on and they are fully acquainted with the whole process. Personnel in developing countries have different conditions, environments, traditions and needs. Therefore, UNIDO ought to stimulate them, through the exchange of experience with each other as well as with their counterparts in industrialized countries, to formulate their own solutions to their own problems.

XXII. CO-OPERATION AMONG UNIVERSITIES, INDUSTRIAL RESEARCH ORGANIZATIONS AND INDUSTRIES, WITH SPECIAL REFERENCE TO THE HUNGARIAN EXPERIENCE

L. Zombory

Two types of higher-level technical educational institutions exist in Hungary - technical universities and technical colleges. The three technical universities, the Technical University of Budapest, the Heavy Industry Technical University of Miskolc and the Chemical Industry University of Veszprem train certified engineers. The technical colleges train works engineers. The period of instruction is, respectively, five and four years, and there are extensive provisions for postgraduate education and training.

In Hungary, 3.2 per cent of national income is devoted to research and some two thirds of this percentage goes for technical research. A long-range scientific research plan for the next 15 years has been formulated and a new financial support system introduced, giving priority to research projects included in the plan.

Universities play a double role in the Hungarian system. On the one hand they do research which is supported by the Government or the Academy of Sciences. On the other, they undertake contract research for industrial and other enterprises. Thus, about half of the total research costs of the Budapest Technical University originates from research contracts. Many of these are long-range agreements with government ministries, large industrial firms and research institutes. The University has direct connections with 28 universities in other countries, mostly those with centrally planned economies and developing countries. One result of these connections is the organization of the Mechanical Engineering Faculty at the Oran Technical University by experts drawn from the Budapest Technical University.

Annex

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